

# TRANSFORMATION OF PRIMARY MINERALS OF CRISTALLINE ROCKS DURING PODZOLISATION PROCESS (TATRA MTS, POLAND)

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**Abstract:** Two podzol profiles developed on weathered Western Tatra granitoides were analysed. The pelitic fractions of the studied soils contain mica, smectite and mixed-layered mica/vermiculite minerals. Chlorite and kaolinite occur in smaller amount. Small amount of quartz and feldspars are also detectable. The content of pelitic fractions in the upper (B<sub>hfe</sub>, E) horizons is near 10 % wt., while in the lower ones (B/C, C) is near 3 % wt. In the soils studied several main processes were recognized they are: vermiculitization of mica and/or chlorite, formation of smectite, formation of kaolinite and probable dissolution of chlorite.

**Key words:** mica–vermiculite, smectite, kaolinite, podzols, Tatra Mts

Podzols are characterised by a naturally low pH value (< 4,5). Their formation occurs with significant contribution of fulvic and humic acids. Podzolisation comprises destruction of primary minerals as well as formation of new phases. In the typical podzol profile several horizons can be distinguished: organic horizon, albic (E) horizon, spodic (B) horizon and parent rock (B/C and C horizons). According to Skiba (1977, 1997) and Lundström et al. (2000) the process of destruction takes place in upper, more acidic soil (E) horizons, while the precipitation of new phases occurs in lower, less acidic (B) horizons. Mineral composition of podzols from different localities was described by several authors (eg. Bain 1977, Wilson et al. 1984, Gustafsson et al. 1995, Righi et al. 1999, Melkerud et al. 2000, Weber et al. 2000).

Several important processes which take place during podzolisation were described. They are the following: formation of smectite and /or vermiculite at the expense of mica and/or chlorite (eg. Righi et al. 1997b), formation of mica/vermiculite regular mixed layered minerals (Bain et al. 1990), probable formation of kaolinite (Carnicelli et al. 1997, Skiba 2001), dissolution of chlorite (Bain 1977) formation of poorly crystallised phases like allophane and immogolite (e.g. Gustafsson et al. 1999) The exact mechanism of those reactions still remains unclear.

Mineralogy of podzols developed from granitic material of the High Tatra granitoides was not studied in detail (Kubisz & Oleksynowa 1972, Oleksynowa & Skiba 1976, Skiba 2001)

The aim of this paper is to present some new data on mineral changes within the podzols profiles developed on the Western Tatra granitoides.

## *Material and methods*

The samples were collected from the two soil profiles developed on the weathered Western Tatra granitoides. The first profile (GM–8) is located on the south western slopes of Trzydniowiański Wierch peak. The second profile (GM–10) is located on the top of the Trzydniowiański Wierch peak.

The samples were subjected to organic matter removal, performed with the use of diluted H<sub>2</sub>O<sub>2</sub> solutions as well as Fe<sup>3+</sup> oxides removal according to Mehra and Jackson (1960) method. All the samples were Na–saturated and dialysed. The pelitic (< 2 μm) fractions were separated by centrifugation. The oriented preparations were obtained by evaporating the water suspensions of the separated clays on glass slides. XRD analyses were performed on the preparations which were air–dried, ethylene glycol vapour–solvated and heated to 200 °C and then to 330 °C.

## *Results*

The content of pelitic fractions in the upper (B<sub>hfe</sub>, E) horizons is near 10 % wt, while in the lower ones (B/C, C) is near 3 % wt. The mineral composition of the clay fraction studied is present on the figures (1A–F)

### *GM–8 Profile*

The fraction contains mica and mixed-layered minerals with swelling interlayers. Chlorite and kaolinite occur in smaller amount. Some small amount of quartz and feldspars are also detectable in the separated fractions.

The amount of mica seems to be more or less the same in the all horizons. Chlorite is present only in the lower B and B/C horizons (reflections near 14Å, 7 Å and 3.52 Å). Kaolinite reflections (7.14Å and 3.58Å) can be seen in all the horizons. The amount of kaolinite increases toward the top of the profile.

The mixed-layered minerals evolve toward the top of the profile. In the lowest B/C horizon only some weak reflections between 14Å and 10Å can be seen (Fig.1B). Some of these reflections shift to the higher positions (near 16Å) after solvation the sample with ethylene glycol vapours, and some remains unaffected. The reflections also disappear almost totally after heating the sample to 200°. It indicates some random mixed-layer minerals which contain smectitic or vermiculitic interlayers respectively. In the B horizon the broad relatively intensive reflection near 12Å can be seen (Fig.1C). Its position remains unaffected with glycol treatment. After heating, it continuously shifts toward 10Å. It may indicate the presence of vermiculitic material with Al-hydroxy interlayers. In the E horizon superstructure reflection (22Å) with rational series of reflections (11Å, 5.5Å, 3.18Å) can be seen (Fig.1A). This rational series is clearly affected by the glycol treatment. After heating to 200 °C the reflections disappear. This behaviour indicates the presence of regularly interstratified mica/low charge vermiculite (M/V)phase.

### *GM–10 profile*

Mica and expandable clay minerals also dominate in the pelitic fractions of this profile. Kaolinite as well as quartz and feldspars occur in smaller amount. The presence of chlorite is doubtful.

The pelitic fractions of the lower (B/C and C horizons contain mica and expanding minerals. The expandables are characterised by the presence of broad basal reflection near 12Å and its rational series (not well seen in the air –dried conditions) (Fig.1F). These reflections are strongly affected by the glycol vapour treatment and the whole rational series is well seen after this operation. After heating to 200 °C, the reflections collapse to 10Å and lower values respectively. The upper horizons B and E show the mineral composition similar to that observed in GM–8 profile. However the “regular” mixed-layered mineral is not so well developed.

## *Discussion and conclusions*

The smectite-like minerals present in the lower horizons (B/C and C) of the studied soil profiles are probably the product of weathering of the granite minerals. Presence of the smectite only in parent material of the studied soils may indicates their formation in early stage of the granites weathering. It is difficult to speculate what was the precursor mineral for the smectite formation. But a very small amount or even lack of chlorite in the GM–10 profile suggests that smectite could have been formed by the weathering of primary chlorites. The absence of smectite in the upper horizons indicates their instability in lower pH. Their dissolution is very probable.

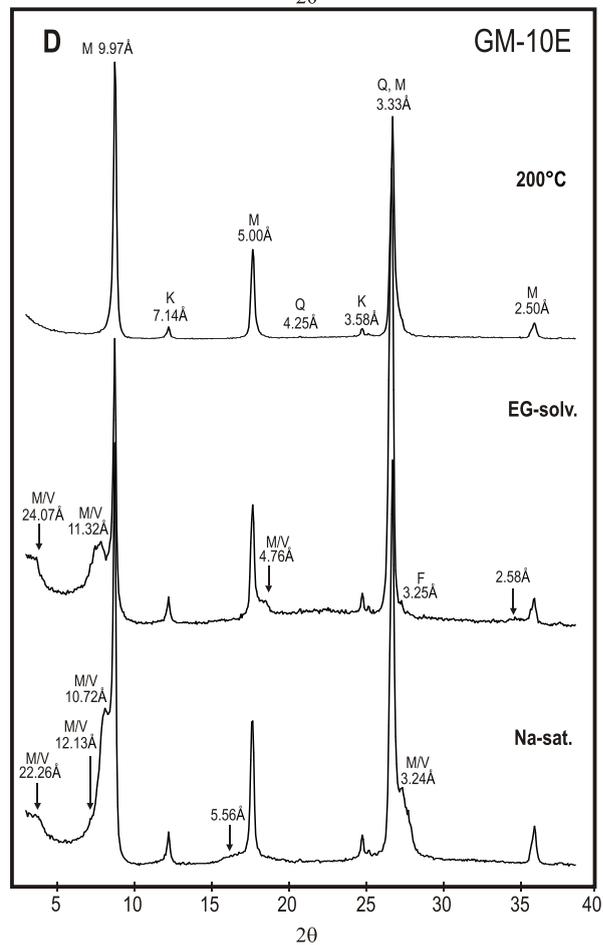
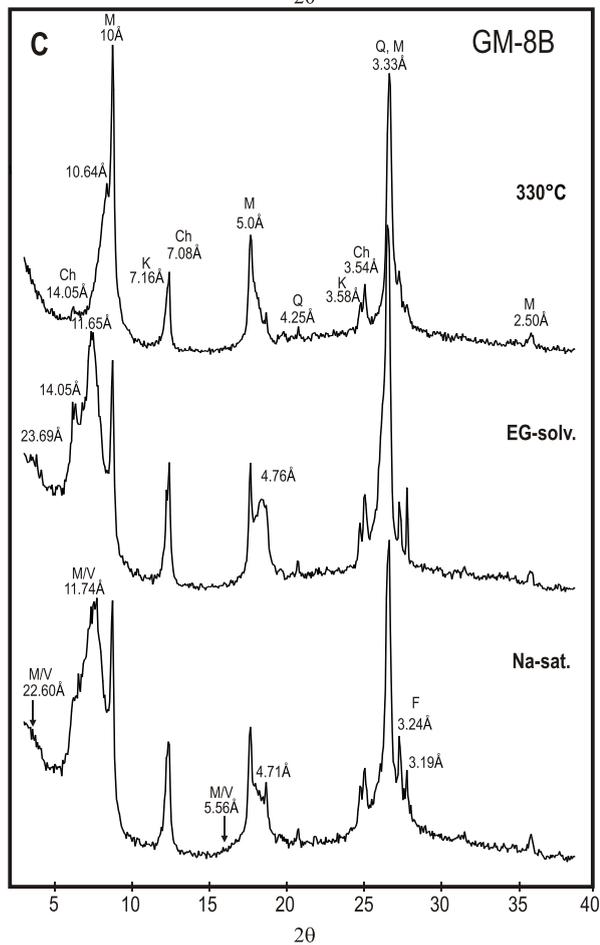
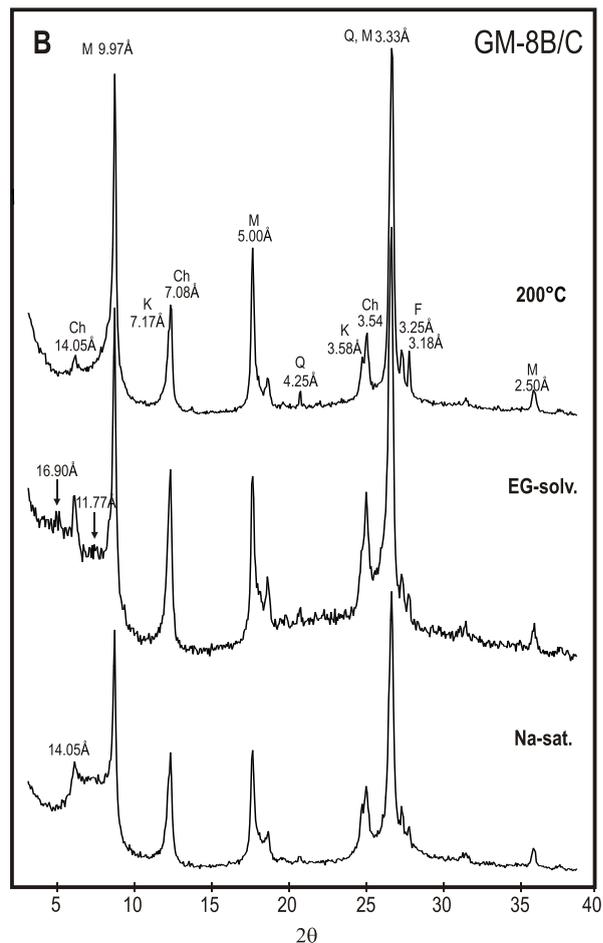
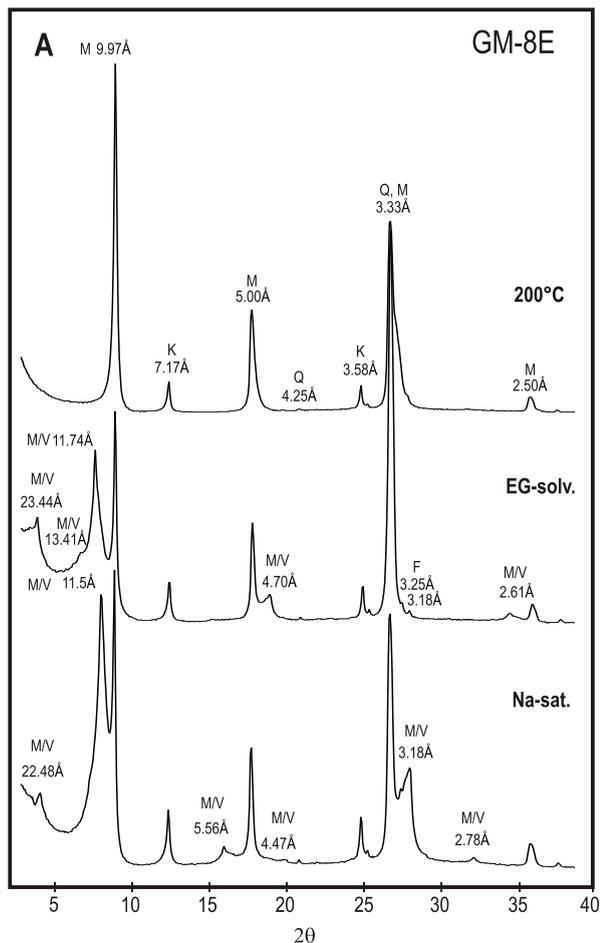
The mica/vermiculite minerals from podzols were described by several authors. According to Bain (1990) their formation occurs at the expense of primary micas. Also, their formation by the chlorite weathering in podzols is probable (Carnicelli et al. 1997). In upper podzol horizons chlorite might be also dissolved without formation of any new phase (Bain 1977). Very small amount of primary chlorite in the GM–10 profile and a relatively high intensities of the M/V reflections may indicate that in this profile the mixed-layer mica/vermiculite minerals are formed in the process of mica weathering. Some of M/V minerals from the GM–8 profile can be formed by the chlorite weathering. The process of chlorite dissolution in the E horizons is also propable.

The presence of kaolinite in the Tatra podzols was widely discussed by Skiba (2001). In the paper several possibilities of kaolinite origin were considered, which resulted in the conclusion that its formation during the weathering and/or podzolisation is most probable. The higher content of the clay fractions in the upper horizon of the studied soils may suggest that those horizons are contaminated by the eolian material. Kaolinite was reported in airborne dusts, collected from the snow cover in the Tatras (Manecki et al. 1978) Thus, the eolian deposition as a supplementary source of kaolinite in the soils studied is worth considering. However, the increase of the clay content in the upper part of the profiles may be connected with degradation of the bigger grains contained in the soil material, joined with concomitant formation of stable particles of clay size. In the studied soils several main processes were recognized they are: vermiculitization of mica and/or chlorite, formation of smectite, formation of kaolinite and probable dissolution of chlorite. Further investigations including HRTEM as well as SEM–EDS observations are needed to explain the nature of these processes.

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**Fig. 1 A. B. C. D. E. F.**



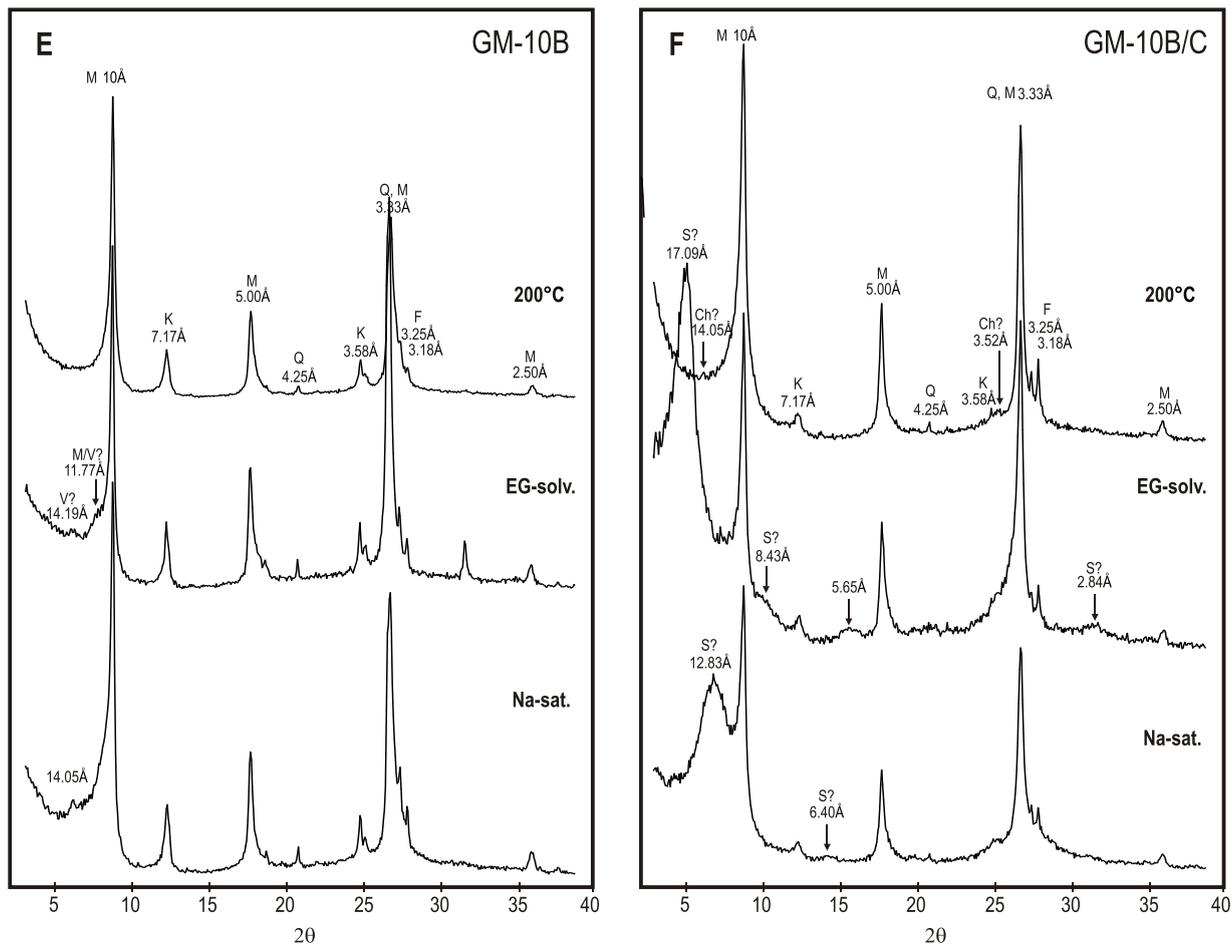


Fig. 1 A-F. Raw X-ray patterns of the soil clays (<2 $\mu$ m). M/V - mixed layerd mica/vermiculite mineral, S - smectite, M-mica, Ch - chlorite, K - kaolinite, Q - quartz, F - feldspars